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16. ABSTRACT

Insofar as highway pavement construction is concerned, it appears that four properties of asphaltic materials will define the necessary engineering requirements. These are: consistency, rate of curing or "setting", durability and resistance to water action.

This report presents the results of tests which appear to provide necessary measurements for evaluation of mixing and service life durability and "setting" characteristics during and immediately following construction.

Two groups of asphalts were used in the test program. The first is composed of forty 85-100 grade paving asphalts from the 1954-55 Bureau of Public Roads test series. The second is a group known as the AC series, which are produced to conform to the 1963 tentative grade requirements of the Asphalt Institute. This series was also furnished by the Bureau of Public Roads.

Changes during mixing were studied using the AASHO Thin Film Oven test and the California Rolling Thin Film test. A satisfactory correlation was found for results obtained by both methods. We conclude that either method will provide a test for determining change in consistency during mixing.

Intensive studies on the development of tests for measuring consistency of paving grade asphalts in the range of 40*F. to 325*F. has led to the development of tentative specifications for specifying grade requirements at 140*F. Further high temperature susceptibility is controlled by a 275*F. viscosity requirement. The purpose of these requirements is to provide uniformity in asphalt viscosity during placement and rolling operations and in service resistance to rutting.

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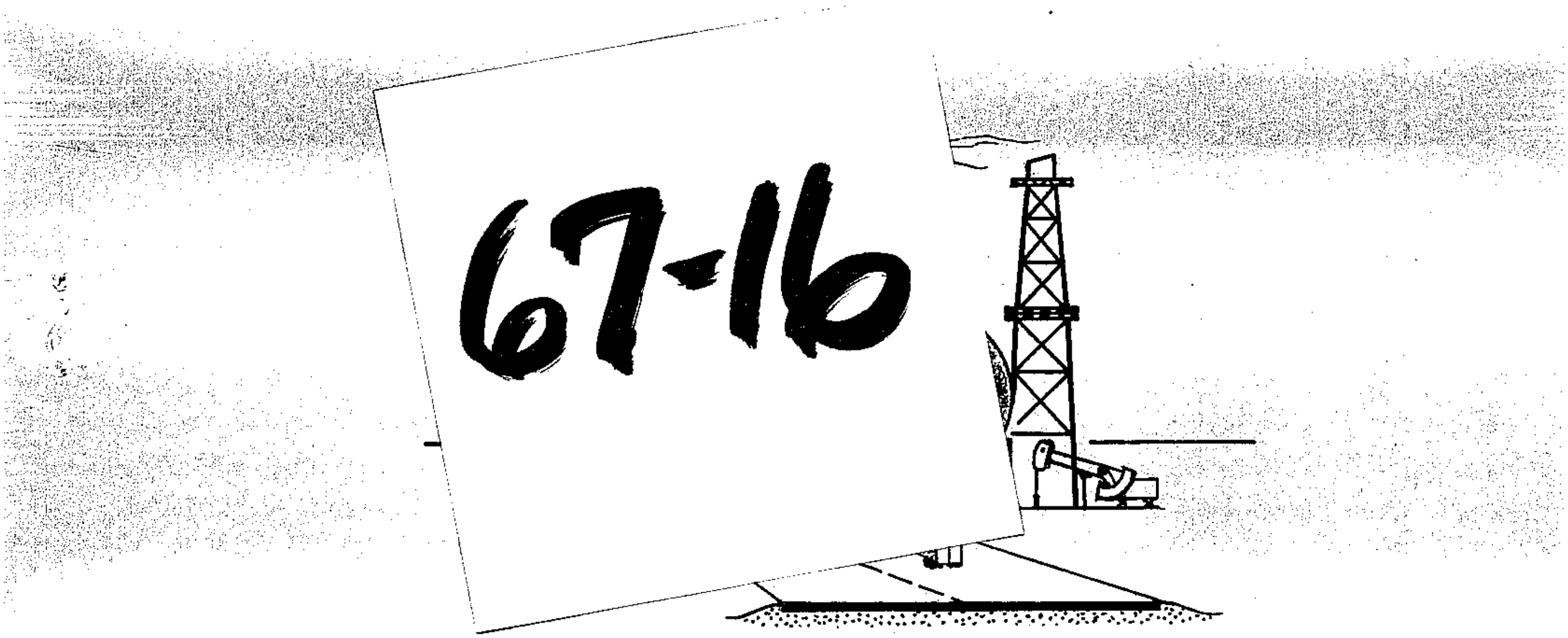

PRESENTED AT THE ANNUAL MEETING OF THE

ASSOCIATION OF ASPHALT PAVING TECHNOLOGISTS

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"SETTING" AND DURABILITY
STUDIES ON PAVING GRADE ASPHALTS

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SYNOPSIS

Insofar as highway pavement construction is concerned, it appears that four properties of asphaltic materials will define the necessary engineering requirements. These are: consistency, rate of curing or "setting", durability and resistance to water action.

This report presents the results of tests which appear to provide necessary measurements for evaluation of mixing and service life durability and "setting" characteristics during and immediately following construction.

Two groups of asphalts were used in the test program. The first is composed of forty 85-100 grade paving asphalts from the 1954-55 Bureau of Public Roads test series. The second is a group known as the AC series, which are produced to conform to the 1963 tentative grade requirements of the Asphalt Institute. This series was also furnished by the Bureau of Public Roads.

Changes during mixing were studied using the AASHO Thin Film Oven test and the California Rolling Thin Film

*Senior Materials and Research Engineer, California Division of Highways, Sacramento, California.

test. A satisfactory correlation was found for results obtained by both methods. We conclude that either method will provide a test for determining change in consistency during mixing.

Intensive studies on the development of tests for measuring consistency of paving grade asphalts in the range of 40°F. to 325°F. has led to the development of tentative specifications for specifying grade requirements at 140°F. Further high temperature susceptibility is controlled by a 275°F. viscosity requirement. The purpose of these requirements is to provide uniformity in asphalt viscosity during placement and rolling operations and in service resistance to rutting.

It is well known that paving grade asphalts change in viscosity during mixing operations, also that asphalts from different sources change at different rates under the same conditions. Results are presented which show that a series of asphalts having original viscosities at 140°F. within a narrow band had a very wide range in viscosity after the Rolling Thin Film test. Most asphalt technologists now consider that the viscosity of the asphalt during placement and rolling operations is a very important parameter for control of the "setting" problem. Information is presented on proposed specification requirements for purchasing asphalt on the basis of viscosity at 140^{o}F. and 275^{o}F. based on the residue from the Rolling Thin Film test.

Tests simulating pavement service life were performed on the two groups of asphalt samples. The forty 85-100 grade paving asphalts were subjected to infrared weathering in an oven for 1000 hours, equivalent to at least five years of service life, and in a modified thin film oven test for durability requirements in our tentative specification. These tests were presented in detail during the 1963 meeting of the Association of Asphalt Paving Technologists. Measurements of changes in properties during and at the conclusion of these tests were performed by determining the abrasion resistance, viscosities at two different shear rates and ductility. Studies of property changes during weathering in the infrared weathering machine indicate that the forty 85-100 grade asphalts from the 1954-55 Bureau of Public Roads test series may be divided into five groups. Some of the asphalts weather very rapidly from volatilization and chemical change while others weather quite slowly as measured by change in consistency, but the shear susceptibility changes very rapidly with a rapid drop in ductile properties. The results indicate that the asphalts weather in different ways and could present different forms of pavement failure.

Both groups of asphalts were tested for compliance with the proposed 1965 California tentative specifications for paving asphalts. Results will be presented together with a further discussion of the proposed specification.

INTRODUCTION

Paving grade asphalt is one of the most versatile materials available to the highway engineer. This adhesive may be used under different construction and weather conditions by controlling the original consistency. This is possible by use of emulsification, additions of solvents or heat.

Although paving asphalt is used in many different forms of road construction, the essential engineering properties that need to be determined by tests and specification requirements appear to be:(1)

1. Consistency.
2. Rate of curing or "setting."
3. Durability.
4. Resistance to water action.

For many years the Materials and Research Department of the California Division of Highways has been associated with both field and laboratory studies on asphaltic materials. These studies have been mainly concerned with attempting to develop tests and specifications for the four previously noted engineering properties. The results of these studies were incorporated in a paper presented at the 1963 meeting of the Association of Asphalt Paving Technologists.(2)

After publication of the 1963 paper, studies have continued on the test methods and the specifications presented in this paper have been modified. Two groups of asphalts were used in the test program. The first group has been described in detail by Welborn and Halstead.(3)(4) This series was obtained by the Bureau in 1954-55 and is composed of asphalts of grades 60-70, 70-85, 85-100, 120-150, and 150-200 penetration. The bulk of the samples were of the 85-100 grade and 40 samples from this group were selected for this study by J. Y. Welborn of the Bureau. This selection was based on previous studies(3)(4), and represented wide differences in crude source and production methods.

The second set, known as the AC series, represent asphalts derived from production sources throughout the United States and were obtained in 1963 and 1964. The materials represent asphalts produced to meet the new proposed Asphalt Institute grading limits based on viscosity at 140°F., measured in absolute units (poises). Four grades (AC5, 10, 20, and 40) are represented.

The purpose of this paper is to present our studies on these asphalts. This report should be considered as a progress report of studies subsequent to the 1963 publication.

CONSISTENCY AND THE "SETTING" OF ASPHALT CONCRETE

Intensive studies on the development of tests for measuring consistency of paving grade asphalts in the range of 40°F. to 325°F. has led to the development of tentative specifications for specifying grade requirements at 140°F.[5] Further, high temperature susceptibility is controlled by a 275°F. viscosity requirement. The purpose of these requirements is to provide better uniformity in asphalt viscosity during placement and rolling operations.

It is well known that paving grade asphalts change in viscosity during mixing operations, and asphalts from different sources change at different rates under the same conditions. This is illustrated in Figure 1 which shows the viscosities of residues from the Rolling Thin Film test [2] for a series of asphalts produced to conform to the AC 20 grade. In this case, the original viscosity at 140°F. was limited to a relatively narrow band. However, after the Rolling Thin Film test, which simulates the changes occurring in the mixer, the range in viscosity at 140°F. is 4500 to 12,000 poises. There is little reason to doubt that the asphalts in this group will provide different degrees of "set" in the same paving mixture.

Most asphalt technologists now consider the viscosity of the asphalt during placement and rolling as a very important parameter for control of the "setting" problem. Therefore, it seems logical to conclude that the highway engineer's first interest in consistency of a paving grade asphalt is the viscosity existing in the paving mixture after mixing has been completed. On the basis of this reasoning, the California Division of Highways has modified the 1963 tentative specification.(6) All original consistency requirements were abandoned and grade requirements were established on the residue from the Rolling Thin Film test. These requirements involve a viscosity range at 140°F. and 275°F.

Previous and continuing studies involving the Cohesiograph(2) indicate that a viscosity range of 4000-6000 poises at 140°F. on the Rolling Thin Film residue will provide an asphalt of satisfactory "setting" properties. This is based on field correlation involving presently used 85-100 grade paving asphalt. It is very interesting to note that independent studies by R. J. Schmidt and Associates(7) have confirmed the above-noted requirement. Santucci and Schmidt state in their conclusions, "The State of California's recommended grading limits of 4.0 to 6.0 kilopoises at 140°F. on an RTF residue correspond to our recommended pavement toughness limits of 30-50 seconds at 100°F. Field experience indicates that mixes having these toughness limits compact and handle well."

Either the Rolling Thin Film test or the AASHO Thin Film test, developed by the Bureau of Public Roads, may be used for simulating the mixing operation. As will be shown later in this report, these tests correlate very well.

DURABILITY STUDIES

The most important property of any adhesive is its ability to act as an effective cementing agent during its service life. In our opinion, the most pressing need in asphalt specifications is the development of suitable control tests and requirements to properly insure satisfactory durability. Our previous study on this property of paving grade asphalts has been presented in detail in reference (2). The results presented, hereafter, have been obtained since publication of the 1963 report.

The present standard test for simulating the field mixing operation is the AASHO Thin Film Oven test developed by the Bureau of Public Roads. Hveem et al[(8)], in a report on the Zaca-Wigmore project, showed an excellent correlation between the AASHO Thin Film Oven test results and hardening during mixing. Other field studies by the Bureau also provide a good correlation. The California Rolling Thin Film test described in reference (2) was calibrated with field mixing by determining the time required to reduce an asphalt to the same penetration as that found after field pug mill mixing. The final time, 75 minutes, was also checked against a previously field calibrated asphalt Ottawa sand mixer. On the basis of these efforts, one would assume that a satisfactory correlation should exist between the AASHO Thin Film Oven test and the California Rolling Thin Film test. Although results presented in reference (2) did show a trend, the correlation was not as satisfactory as expected on the basis of the field calibration studies.

In order to obtain more information on the degree of correlation between the two tests, results from the 1954 Bureau and AC series were compared. The results are shown in Tables A and B and Figures 2, 3, 4 and 5. Figure 2 presents a comparison of the residue penetration for the 1954 Bureau series which was composed of asphalts of the 85-100 grade. The correlation is quite good considering the fact that results for the AASHO Thin Film Oven test were determined by the Bureau laboratory in

Washington, D.C., while the California Rolling Thin Film test results were obtained in the Sacramento laboratory of the California Materials and Research Department. Figures 3, 4 and 5 present comparisons of penetration, and kinematic viscosities at 140°F. and 275°F. for the AC series. The results indicate a good correlation between the two tests in terms of penetration. However, the California Rolling Thin Film test shows a slightly greater hardening when kinematic viscosities at 140°F. and 275°F. are compared.

We conclude from the results of studies on both the 1954 Bureau and AC series of asphalts that a satisfactory correlation exists between the AASHO Thin Film Oven test and the California Rolling Thin Film test. Both of the tests provide a method of control for changes occurring in the binder during the mixing process. The California Rolling Thin Film test appears to provide an advantage for control testing because of the reduced time period of only one hour and fifteen minutes as compared to the five hour period required in the AASHO test.

The 1954 Bureau series of 85-100 grade asphalts were subjected to a 1000 hour weathering period using the method previously described by Skog.[9] In this method, a two per cent asphalt - Ottawa sand mix is prepared in a laboratory mixer, and is then weathered in the infrared weathering unit. This unit has been correlated with field service time and 1000 hours in the machine has been found equivalent to approximately five years of service life under pavement conditions estimated to produce a fairly rapid weathering rate.(2) Changes in original properties of the binder as the result of weathering were determined by the Shot Abrasion test(9) and measurements of viscosity, shear susceptibility and micro-ductility.(2) Test results after mixing and 1000 hours of weathering are shown in Table C. A study of the results indicate that the asphalts may be divided into five general groups as shown in Tables D and E. The property changes during mixing and weathering are illustrated for each group in Figures 6, 7, 8, 9 and 10.

Asphalts in Group I are those having a low flash point and a high thin film loss. It is probable that the very rapid weathering rate is caused by loss of volatiles. Asphalts in Groups II, III, IV and V show high or very high flash results with low loss values, but their weathering properties are different. In the case of Group II, the rapid weathering rate appears to be caused by chemical change with loss of volatiles contributing little to the change. Asphalts in Group III have a moderate hardening rate, and moderate rate of change in shear index. We note that the micro-ductility drop is fairly rapid from high initial values. Group IV asphalts have low weathering rates as measured by abrasion loss and viscosity, but the shear index shows a moderate to very high rate of change during mixing and weathering in the infrared machine. These asphalts also have a relatively high original shear index. There is a rapid drop from initial low micro-ductilities to very low results after weathering. The Group V asphalts have a low to moderate hardening rate. The initial shear index is low and the rate of change during mixing and weathering remains very low. These asphalts have a high initial micro-ductility with a slow rate of change during weathering.

There are reasons to believe that the different groups of asphalts will show differences in service performance. The rapid hardening rate coupled in some cases with critical increases in shear index of Groups I and II asphalts could lead to different forms of cracking, especially where deflection results are above critical values. The Group IV asphalts could possibly present problems with raveling and cracking of the type described by P. C. Doyle.(10)(11) The change in shear index during weathering of the Group IV asphalts is compared in Figure 11 with the three Doyle asphalts whose service performance was reported in reference (10). The results of all of the asphalts are above the satisfactory curve for the Doyle asphalt "C". However, most of them fit between the failed asphalt "B" and the satisfactory material "C". The asphalts in Group V have very different properties from those of Group IV. They remain virtually Newtonian through an extended weathering period. This type of asphalt is quite low in asphaltenes and in the micro-ductility test shows a gain in ductility through the mixing process and sometimes into the weathering phase. Certain recovered asphalts from the Zaca-Wigmore test road also show this trend during service life. As noted in Figure 10 the initial gain is followed by a reduction, but not to the degree found in asphalts of the other groups.

We are of the opinion that a satisfactory asphalt should have balanced engineering properties. In this case, the Group III asphalts appear to be closest to this concept in terms of durability. However, based on our previous studies, we did not expect the micro-ductility to fall to such low values after 1000 hours of weathering. The determination of the service performance of these asphalts, together with the Group IV materials, would be very valuable in future specification developments, and in research on the internal phase relationships of asphaltic constituents and the importance of this relation on the serviceability of the asphalt.

DISCUSSION OF PROPOSED CALIFORNIA SPECIFICATION

A tentative specification for paving grade asphalt was presented to the industry in 1963.[2] The purpose of this specification was to attain satisfactory "setting" and durability properties, and to attain a balance between these properties. Because of lack of a suitable test, no requirements were written for resistance to water action.

Subsequent studies have led to a modification of the proposed specification as shown in Table F.[12] At the present time, only one grade is specified.

The most important modification is the elimination of all requirements for consistency of the original material. The grade of the material is determined by a viscosity measurement at 140°F. on the residue from a test which simulates the mixing process (RTFOT). This measurement, when coupled with a 275°F. requirement, assures uniformity of the binder viscosity, and elevated temperature susceptibility during placement and rolling operations.

We wish to stress that this modification would not be acceptable without a test for pavement durability. The use of this modification permits the manufacturer to use any consistency for his original product, and there is no control over the changes occurring during mixing since only a residue consistency range is specified. However, any rapidly changing asphalt that continued to change after the test simulating pug mill mixing would be rejected in the durability test.

The durability test requirements are proposed in order to attain control over property changes during service life. This test is described in detail in reference (2). On the basis of a correlation with the infrared weathering machine, we may state that tests on the residue from this method are equivalent to those attained after at least five years of service life.

Hardening of the binder during service life is controlled by the viscosity requirement at 0.05 sec^{-1} shear rate. It will be noted that the viscosity test is performed at 77°F. In our opinion this provides a measure of control over the temperature susceptibility in the 40-140°F. range. Materials of satisfactory temperature susceptibility above 140°F., but with a high susceptibility at low temperatures would have a high viscosity at 77°F. after the Rolling Thin Film test. Such a material would have to be very durable to comply with the durability test requirements at the 0.05 sec^{-1} shear rate.

On the basis of the failures reported by Doyle[10] and Hveem, et al[2] it appears necessary to control the gain in shear susceptibility during service life. This is proposed in the tentative specification by a durability residue maximum viscosity at 0.001 sec^{-1} shear rate. It could also be controlled by specifying a maximum shear index value.

The third measurement on the residue from the durability test is the ductility determination. One of the most debated methods for controlling asphalt quality is the importance and significance of the ductility test. However, results reported in the literature[13][14][15][16][17][18] from various field and laboratory investigations clearly indicate that a decrease in ductile properties during weathering, as measured by the standard test, is related to failure of the pavement.

The weathering results previously reported in this paper indicate that the change in ductility during weathering appears to be caused by hardening or a change in shear index or a combination of the two. This is shown in Figure 12. We note that there is a good relation between shear index and micro-ductility on durability test residues, except in cases where the viscosity of the residue is very high. The finding of a good relation between durability residue shear index and micro-ductility for moderate weathering rate asphalts confirms the studies recently reported by Welborn[19] et al. It seems apparent that the development of a high shear index during weathering may have been the cause of failures previously reported in the literature as being concerned with a decrease in ductility values. These findings are directly related to Halstead's study[18] in which he states: "Therefore, it is most likely that the ability of the asphalt to undergo elongation is not the primary characteristic affecting durability, but rather the ductility test result is an indication of an internal phase relationship of the asphaltic constituents which in turn have an important bearing on the serviceability factors of the asphalt." This statement is supported by the relation between shear index and micro-ductility as reported in this paper. Further evidence is provided by the trend found between the shear index after weathering and the stain number of the original asphalt as shown in Figure 13. Both of these factors are related to the internal phase relationship of the asphaltic constituents.

It is apparent that the control of gain in shear susceptibility during weathering is a necessary specification requirement. This control may be achieved, as previously noted, by Welborn[19], by either specifying a ductility or a shear index requirement. In our opinion, the determination of the service performance of asphalts weathering like the Group III and IV materials previously mentioned in this report, would provide very valuable results for future specification developments since they represent a range in shear susceptibility during weathering. The proper balance in engineering properties of a paving grade asphalt requires information on the maximum shear index that may be tolerated prior to possible cracking of the pavement.

In order to obtain further information on the specification requirements, tests were performed on the 1954 Bureau 85-100 asphalts and the AC series. The results are compared with the specification requirements in Tables G and H. The results indicate that the asphalts vary quite markedly in properties as defined by the proposed specifications. In Table I are shown the test results for eight asphalts from both test series which comply with the specifications except for the micro-ductility requirement. The ninth asphalt, an AC20, Bureau #3014 complies with all requirements. All eight asphalts have satisfactory durability, but develop a sufficiently high shear index during the durability test to cause failure to comply with the micro-ductility requirement. As shown in Figure 12, the development of a shear index above 0.23 during the course of the durability test will result in a micro-ductility reading below 10. It appears that only small chemical changes in some asphalts may induce a rapid change in internal phase relationships leading to an increase in shear susceptibility. It is apparent that a very important problem in the attainment of balanced engineering properties in a paving grade asphalt is the determination of the maximum shear susceptibility that may be tolerated prior to pavement cracking.

SUMMARY

1. A satisfactory correlation exists between the AASHO Thin Film Oven test (TFOT) and the California Rolling Thin Film Oven test (RTFOT). Both of the tests provide methods of control for changes in the binder during the mixing process.

2. Specification requirements to provide proper "setting" are presented. These requirements are based on controlling grade and the "setting" property by specifying viscosity ranges in absolute units at 140°F. and 275°F. on the residue from the California Thin Film test. These requirements will insure an asphalt of more uniform consistency in the paving mixture than is now attained by present or other proposed specifications.

3. The laboratory weathering of forty 85-100 grade paving asphalts representing various crude sources and methods of manufacture indicates that these materials may be divided into five groups based on changes in properties. Some of the asphalts harden rapidly by either volatile loss or chemical change. Others change in their internal phase relationship as measured by rapid increase in shear susceptibility and loss of ductile properties. Although all of these asphalts meet current specifications, their weathering characteristics are quite different, and in some cases, could possibly lead to different types of pavement failure.

4. Results of tentative specification tests on the 1954 Bureau and AC series indicate that these asphalts

have rather varied engineering properties. One asphalt, from the AC20 group, complied with the new California requirements while eight asphalts complied except for the micro-ductility. This study indicates that a most important problem in asphalt specification requirements is the determination of the maximum amount of shear susceptibility that may develop in a paving grade asphalt prior to pavement failure.

The opinions, findings, and conclusions expressed in this publication are those of the author and not necessarily those of the Bureau of Public Roads.

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TABLE A

Comparison of Residue Test Results From
California Rolling Thin Film and AASHO Thin Film Oven Tests
Bureau Series, 85-100 Grade

Sacto. Res. No.	Bureau No.	AASHO Thin Film Oven			Rolling Thin Film	
		Test	Residue*		Test Residue	
		Loss	Pen.77°F	Duct.77°F	Pen.77°F	Duct.77°F
3680	2	2.04	38	250+	41	100+
3681	3	0.55	52	138	48	100+
3682	4	0.75	48	200	51	100+
3683	6	+0.10	61	250+	57	100+
3684	10	0.02	61	250+	61	100+
3685	13	0.18	55	175	55	100+
3686	17	+0.04	61	205	56	100+
3687	18	0.08	57	29	56	100+
3688	19	0.03	58	148	56	100+
3689	30	0.45	53	70	54	100+
3690	33	0.12	59	117	53	100+
3691	35	0.59	50	71	50	94
3692	38	0.00	56	120	53	100+
3693	40	0.11	50	250+	49	100+
3694	45	0.17	60	200	55	100+
3695	50	0.09	51	166	55	100+
3696	56	+0.03	53	13	52	16
3697	66	0.00	58	80	55	100+
3698	69	+0.02	53	178	49	100+
3699	71	+0.08	61	190	59	100+
3700	72	0.28	58	35	54	32
3701	74	+0.03	64	181	60	100+
3702	76	0.70	57	20	59	18
3703	81	+0.08	63	80	57	79
3704	84	0.31	69	232	74	100+
3705	87	+0.05	55	162	56	100+
3706	89	+0.09	64	160	63	100+
3707	91	0.05	56	190	57	100+
3708	92	0.42	50	242	53	100+
3709	93	0.02	58	250+	64	100+
3710	96	0.09	56	250+	56	100+
3711	100	1.03	43	125	53	100+
3712	101	0.08	57	170	58	100+
3713	103	1.63	39	61	45	84
3714	105	0.30	47	235	51	100+
3715	108	+0.07	54	219	51	100+
3716	109	+0.10	50	63	50	59
3717	111	+0.12	51	214	48	100+
3718	115	0.07	57	71	55	94
3719	119	2.18	35	250+	43	100+

*From - "Properties of Highway Asphalts - Part I, 85-100 Penetration Grade"; J. Y. Welborn and W. J. Halstead, Public Roads, Vol. 30, P. 197, 1959.

TABLE B

Comparison of Residue Test Results From California Rolling Thin Film and AASHO Thin Film Oven Tests

AC Test Series

Sacto Res. No.	Bureau No.	Grade	AASHO Thin Film Oven Test				Rolling Thin Film Test			
			Pen. 77°F	Duct. 77°F	Viscosity 140°F Poises	Viscosity 275°F CS	Pen. 77°F	Duct 77°F	Viscosity 140°F Poises	Viscosity 275°F CS
3912	B2908	GRADE AC5	74	185	1943	371	70	100+	2091	386
3943	B2920		77	216	1743	390	68	100+	1870	405
3916	B2958		101	220	1882	405	100	100+	2002	420
3945	B2962		112	220+	1508	334	105	100+	1601	343
3920	B2974		38	68	1709	347	37	53	1648	349
3922	B3008		90	230	1504	347	70	100+	1491	356
3947	B3012		108	228	1157	353	112	100+	1147	371
3949	B3028		73	225	2024	363	89	100+	2039	370
3927	B3037		96	250+	1027	301	85	100+	1058	300
3928	B3050		103	225+	2212	474	(176)	100+	1800	442
3932	B3054		54	193	1506	351	47	100+	1503	305
3936	B3058		115	220+	1443	368	93	100+	1565	391
3940	B3108		67	234	2377	389	78	100+	1742	344
4080	B3578		72	250+	1904	293	76	100+	1604	266
4076	B3601		94	250+	999	191	90	100+	1076	290
3913	B2909	GRADE AC10	51	201	3908	497	38	100+	3968	499
3944	B2921		54	250+	3054	506	53	100+	3485	535
3917	B2959		70	170	4039	634	65	81	4541	682
3946	B2963		71	250+	3135	465	67	100+	3507	494
3921	B2975		23	24	3735	490	22	17	4025	514
3923	B3009		61	213	4089	508	69	100+	4178	550
3948	B3013		77	250+	2316	493	73	100+	2522	520
3950	B3029		60	250+	3497	463	53	100+	4089	504
3952	B3036		56	250+	2360	441	49	100+	2463	450
3929	B3051		75	220+	3826	634	68	100+	4387	684
3933	B3055		35	180	2568	397	33	100+	2962	424
3937	B3059		70	250+	2954	509	60	100+	3449	533
3941	B3109		55	250+	3397	486	53	100+	3449	485
4081	B3579		49	250+	1984	417	56	100+	2399	329
4077	B3602		51	250+	2235	275	48	100+	2592	196

TABLE B-Continued

Comparison of Residue Test Results From California Rolling Thin Film and AASHO Thin Film Oven Tests

AC Test Series

Sacto. Res. No.	Bureau No.	Grade	AASHO Thin Film Oven Test				Rolling Thin Film Test			
			Pen. 77°F	Duct. 77°F	Viscosity 140°F Poises	Viscosity 275°F CS	Pen. 77°F	Duct. 77°F	Viscosity 140°F Poises	Viscosity 275°F CS
3914	B2910	GRADE AC20	39	148	7047	640	26	90	7707	654
3915	B2922		34	156	7038	678	28	52	7706	692
3918	B2960		56	159	5479	749	50	100+	5938	768
3919	B2964		47	250+	6311	649	41	100+	7366	689
3924	B3010		50	102	9293	735	46	35	10718	790
3925	B3014		53	250+	4331	671	47	100+	4965	692
3926	B3030		37	168	9703	750	31	100+	11750	795
3951	B3035		33	225+	5404	624	39	100+	5488	633
-	B3038		52	52	9589	723	-	-	-	-
-	B3039		49	73	11046	812	-	-	-	-
3930	B3052		50	250+	7853	903	58	100+	8280	947
3934	B3056		24	137	5300	564	28	90	5563	576
3938	B3060		45	250	8339	808	40	100+	7703	800
3942	B3110		41	213	6424	637	43	100+	6755	639
4082	B3580		32	250+	5627	479	38	100+	5117	449
4078	B3603		32	250+	4210	365	31	100+	4574	386
-	B3040	GRADE AC40	43	72	14267	900	-	-	-	-
-	B3040A		32	9	64652	1246	-	-	-	-
3931	B3053		29	119	16143	1278	31	100+	18818	1332
3935	B3057		9	49	10451	761	13	0	12612	827
3939	B3061		28	250+	14539	1055	31	100+	18321	1149
4079	B3604		19	250+	5786	515	21	100+	10433	582

TABLE C
Change in Physical Properties of Bureau 85-100 Test Series After Mixing and Weathering for 1000 Hours in the Infrared Weathering Unit

Sacto. Res. No	Bureau No.	Crude Source	Abrasion Loss Gms. at 77°F			Viscosity, M.P. 77°F, S.R.=0.05Sec^{-1}			Shear Index			Micro Ductility mm at 77°F			Remarks
			Orig	After mix.	After 1000 Hrs.	Orig	After mix.	After 1000 Hrs.	Orig	After mix.	After 1000 Hrs.	Orig	After mix.	After 1000 Hrs.	
3680	2	Venezuela	8	18	94	1.0	7	190	0.00	0.09	0.27	55	55	0	Low flash High loss
3681	3	Mexico	4	7	36	1.2	6	54	0.08	0.16	0.44	53	46	1	
3682	4	Venezuela	8	12	58	1.2	6	78	0.14	0.18	0.37	43	45	2	
3683	6	Columbia	5	8	21	1.0	5	24	0.06	-	0.22	48	53	8	
3684	10	Coastal	3	5	19	1.1	5	24	0.09	0.10	0.27	41	30	6	
3685	13	Venezuela	7	10	57	1.2	5	76	0.09	0.16	0.37	49	33	2	
3686	17		4	8	29	1.0	7	30	0.06	0.06	0.30	50	41	4	
3687	18	—	2	3	11	2.1	6	16	0.11	0.28	0.43	16	5	1	
3688	19	Venezuela	6	7	26	1.2	5	28	0.04	0.17	0.34	42	41	3	
3689	30	Mississippi	2	2	11	1.4	7	23	0.15	0.23	0.46	34	11	1	
3690	33	"	4	5	22	1.3	5	22	0.12	0.16	0.44	31	13	3	
3691	35	"	2	2	11	1.4	6	24	0.15	0.24	0.45	35	18	3	
3692	38	Midcontinent	3	4	18	1.3	7	23	0.03	0.06	0.39	33	39	3	
3693	40	Wyoming	9	13	37	1.1	7	31	0.11	0.12	0.27	40	14	4	
3694	45	Arkansas	4	5	15	1.3	5	19	0.03	0.03	0.26	49	54	7	
3695	50	No. & West Texas	6	12	36	1.0	5	36	0.04	0.05	0.28	28	61	5	
3696	56	Kansas	2	3	11	2.5	10	20	0.11	0.41	0.62	16	3	3	
3697	66	"	2	4	13	1.6	5	19	0.12	0.12	0.40	25	19	4	
3698	69	Texas	13	18	44	1.2	8	31	0.04	0.04	0.28	32	45	4	
3699	71	Midcontinent	10	12	31	1.1	6	20	0.02	0.00	0.17	43	56	8	
3700	72	Oklahoma	2	2	8	1.5	9	16	0.07	0.39	0.50	18	5	2	
3701	74	Texas	2	2	12	1.0	3	15	0.09	0.11	0.28	36	47	6	
3702	76	Oklahoma	1	1	12	1.8	6	24	0.18	0.31	0.51	20	9	2	
3703	81	Texas, Kansas	1	3	10	1.4	7	24	0.20	0.29	0.49	25	10	2	
3704	84	Gulf Coast	4	5	14	0.7	2	8	0.07	0.08	0.03	44	47	40	
3705	87	Oklahoma	4	6	16	1.3	7	19	0.08	0.12	0.31	36	21	5	
3706	89	Arkansas	3	4	13	1.2	3	18	0.00	0.09	0.24	46	67	7	
3707	91	California	9	14	40	0.9	2	24	0.00	0.00	0.02	40	65	28	
3708	92	"	12	17	69	1.0	8	120	0.00	-	0.33	43	72	1	
3709	93	"	9	13	35	0.8	3	23	0.03	0.02	0.00	53	-	36	
3710	96	"	14	20	68	1.0	7	78	0.03	0.04	0.18	47	66	1	

TABLE C (Continued)
Change in Physical Properties of Bureau 85-100 Test Series After Mixing and Weathering for 1000 Hours in the Infrared Weathering Unit

Sacto. Res. No.	Bureau No	Crude Source	Abrasion Loss Gms. at 77°F			Viscosity, M.P. 77°F, S.R.=0.05Sec^{-1}			Shear Index			Micro Ductility mm at 77°F			Remarks
			Orig	After mix	After 1000 Hrs.	Orig.	After mix	After 1000 Hrs.	Orig.	After mix	After 1000 Hrs.	Orig.	After mix	After 1000 Hrs.	
3711	100	California	8	13	81	1.2	4	218	0.12	0.18	0.44	46	34	0	Low flash High Loss
3712	101	Montana	8	9	30	1.1	7	25	0.04	0.06	0.35	28	34	3	
3713	103	California	7	18	86	1.3	10	290	0.15	0.24	0.44	27	21	0	Low flash High Loss
3714	105	Wyoming	7	11	44	1.0	6	36	0.10	0.10	0.36	34	42	3	
3715	108	"	9	14	52	1.1	8	40	0.06	0.08	0.27	32	39	4	
3716	109	Colorado	2	5	15	2.1	7	17	0.02	0.27	0.46	23	8	2	
3717	111	Wyoming	5	9	24	1.4	8	21	0.02	0.17	0.34	38	28	6	
3718	115	Texas, Kansas	3	3	14	1.4	7	28	0.18	0.27	0.46	22	18	2	
3719	119	Colorado	11	21	130	1.0	7	160	0.17	-	0.31	37	-	0	Low flash. High Loss.

TABLE D

Physical Properties of Bureau 85-100
Test Series

Physical Properties	Asphalt		
	Sacto. No.	Bureau No.	Crude Source
Group I Low Flash, High Thin Film Loss, Rapid Hardening Rate, Moderate to High Rate of Change in Shear Index. Rapid Drop in Micro-ductility to Very Low Values.	3680 3711 3713 3719	2 100 103 119	Venezuela California California Colorado
Group II Normal Flash, Low Thin Film Loss, Rapid Hardening Rate, Variable Rate of Change in Shear Index, Quite Rapid Drop in Micro-ductility to Values Below 3mm at End of Weathering Period.	3682 3685 3708 3710 3681	4 13 92 96 3	Venezuela Venezuela California California Mexico
Group III Moderate Hardening Rate and Moderate Rate of Change in Shear Index. Micro-ductility Drop is Fairly Rapid, from High Initial Values.	3683 3684 3686 3688 3692 3693 3694 3695 3698 3699 3701 3705 3706 3712 3714 3715 3717	6 10 17 19 38 40 45 50 69 71 74 87 89 101 105 108 111	Columbia Coastal - Venezuela Midcontinent Wyoming Arkansas North & West Texas Texas Midcontinent Texas Oklahoma Arkansas Montana Wyoming Wyoming Wyoming
Group IV Low Hardening Rate, Moderate to Very High Rate of Change in Shear Index. High Initial Shear Index Values. Rapid Drop from Initial Low Micro-ductility Readings to Very Low Results After Weathering.	3687 3689 3690 3691 3696 3697 3700 3702 3703 3716 3718	18 30 33 35 56 66 72 76 81 109 115	- Mississippi Mississippi Mississippi Kansas Kansas Oklahoma Oklahoma Texas, Kansas Colorado Texas, Kansas

TABLE D (continued)

Physical Properties of Bureau 85-100
Test Series

Physical Properties	Asphalt		
	Sacto. No.	Bureau No.	Crude Source
Group V Low to Moderate Hardening Rate. Very Low Rate of Change in Shear Index. High Initial Micro-ductility with Slow Rate of Change During Weathering.	3704 3707 3709	84 91 93	Gulf Coast California California

TABLE E

Physical Properties of Bureau 85-100 Test Series After Weathering for 1000 hours in the Infrared Weathering Unit

Group	Sacto No	Bureau No.	Asphalt Properties After 1000 Hrs. Weathering				Total Change in Properties, Orig-1000 hrs.		
			Abra. Loss	Visc. 0.05 Sec^{-1}	Shear Index	Micro Duct	Abra. loss	Visc. 0.05 Sec^{-1}	Shear Index
I	3680	2	94	190	0.27	0	86	189	0.27
	3711	100	81	218	0.44	0	73	217	0.32
	3713	103	86	290	0.44	0	79	289	0.29
	3719	119	130	160	0.31	0	119	159	0.14
II	3682	4	58	78	0.37	2	50	77	0.23
	3685	13	57	76	0.37	2	50	75	0.28
	3708	92	69	120	0.33	1	57	119	0.33
	3710	96	68	78	0.18	1	54	77	0.15
	3681	3	36	54	0.44	1	32	53	0.36
III	3683	6	21	24	0.22	8	16	23	0.16
	3684	10	19	24	0.27	6	16	23	0.18
	3686	17	29	30	0.30	4	25	29	0.24
	3688	19	26	28	0.34	3	20	27	0.30
	3692	38	18	23	0.39	3	15	22	0.36
	3693	40	37	31	0.27	4	28	30	0.16
	3694	45	15	19	0.26	7	11	18	0.23
	3695	50	36	36	0.28	5	30	35	0.24
	3698	69	44	31	0.28	4	31	30	0.24
	3699	71	31	20	0.17	8	21	19	0.15
	3701	74	12	15	0.28	6	10	14	0.19
	3705	87	16	19	0.31	5	12	18	0.23
	3706	89	13	18	0.24	7	10	17	0.24
	3712	101	30	25	0.35	3	22	24	0.31
	3714	105	44	36	0.36	3	37	35	0.26
	3715	108	52	40	0.27	4	43	39	0.21
	3717	111	24	21	0.34	6	19	20	0.32
IV	3687	18	11	16	0.43	1	9	14	0.32
	3689	30	11	23	0.46	1	9	22	0.31
	3690	33	22	22	0.44	3	18	21	0.32
	3691	35	11	24	0.45	3	9	23	0.30
	3696	56	11	20	0.62	3	9	17	0.51
	3697	66	13	19	0.40	4	11	17	0.28
	3700	72	8	16	0.50	2	6	14	0.43
	3702	76	12	24	0.51	2	11	22	0.33
	3703	81	10	24	0.49	2	9	23	0.29
	3716	109	15	17	0.46	2	13	15	0.44
	3718	115	14	28	0.46	2	11	27	0.28
V	3704	84	14	8	0.03	40	10	7	-
	3707	91	40	24	0.02	28	31	23	0.02
	3709	93	35	23	0.00	36	26	22	-

TABLE F

May 1965

COMPARISON OF PRESENT TENTATIVE SPECIFICATION FOR 85-100 GRADE PAVING ASPHALT AND PROPOSED MODIFIED REQUIREMENTS

TEST	PRESENT TENTATIVE SPECIFICATION	PROPOSED MODIFIED SPECIFICATION
FLASH POINT, P.M.C.T. °F MIN.	475	475
PENETRATION OF ORIGINAL SAMPLE AT 77°F	85-100	—
STAIN NUMBER OF ORIGINAL SAMPLE MAX. AFTER 120 HRS.-140°F-50#/SQ.IN.	10	10
VISCOSITY, C.S. ON ORIGINAL SAMPLE		
140°F. MINIMUM X 10^5	2.2	—
225°F. MINIMUM	1800	—
325°F. MAXIMUM	200	—
COHESIOGRAPH READING-ORIG.MIN.IN.	0.80	—
GAIN 0-24 HRS. MIN. IN.	0.08	—
ROLLING THIN FILM TEST 325°F., 75 MIN.		
PEN. RESIDUE, 77°F., MIN.	55	—
DUCT. RESIDUE, 77°F., MIN.	75	75
VISCOSITY		
140°F., POISES	—	4,000-6,000
275°F., CENTISTOKES	—	425-800
DURABILITY TEST		
VISCOSITY OF RESIDUE AFTER DURABILITY TEST, MEGAPOISES AT 77°F.		
SHEAR RATE 0.05 SEC. $^{-1}$ MAX	20	25
SHEAR RATE 0.001 SEC. $^{-1}$ MAX	60	60
MICRO DUCTILITY OF RESIDUE 1/2 C M / MIN. MINIMUM, MM	10	10
SOLUBILITY, CCL_4, ORIG. SAMPLE, % MIN.	99	99
ROLLING THIN FILM TEST, 375°F.-75 MIN		
PEN. RESIDUE 77°F., MIN	45	—
DUCT. RESIDUE, 77°F., MIN	60	—

TABLE G

Tentative Specification Test Results on Bureau 85-100 Grade Test Series

Sacto. Res. No.	Bureau No.	Original Sample Tests				Rolling Thin Film Test			Durability Test		
		Pen. 77°F	Flash PMCT	Visc. 140°F Poises	Stain No.	Viscosity 140°F Poises	Viscosity 275°F CS	Stand. Duct. cm.	Viscosity SR=0.05 Sec^{-1} M.P.	Viscosity SR=0.001 Sec^{-1} M.P.	Micro-Ductility mm
Specification Requirements		-	475 Min	-	10 Max	4000-6000	425-800	75 Min	25 Max	60 Max	10 Min
3680	2	88	370	1510	7.5	4700	445	100+	244	660	1
3681	3	87	445	3570	9	11130	1102	100+	26	97	4
3682	4	87	435	2410	9	7520	828	100+	44	125	3
3683	6	86	525	1940	7	3310	460	100+	12	20	39
3684	10	91	520	1760	8.5	3610	520	100+	12	26	10
3685	13	89	480	2280	7	5950	762	100+	27	90	4
3686	17	93	535	1630	6.5	3610	451	100+	17	41	32
3687	18	87	425	2900	11.5	11060	760	100+	10	41	4
3688	19	94	510	1930	8.5	4850	575	100+	18	43	8
3689	30	91	440	2960	13.5	12580	822	100+	21	94	2
3690	33	96	470	2270	13	6710	712	100+	15	44	4
3691	35	92	420	3370	11.5	13460	911	94	21	98	3
3692	38	90	510	1520	7.5	4230	519	100+	12	39	5
3693	40	83	435	1390	7	3590	454	100+	20	47	12
3694	45	90	545	1510	7.5	3620	546	100+	11	29	13
3695	50	98	435	990	6.5	2030	357	100+	19	46	15
3696	56	86	525	1970	13	15130	547	16	12	73	2
3697	66	90	485	2100	7.5	6400	653	100+	12	52	4
3698	69	87	535	930	6.5	2060	318	100+	26	65	15
3699	71	87	525	1490	5.5	2420	432	100+	9	11	70
3700	72	95	455	2220	11.5	9750	616	32	17	113	2
3701	74	94	525	1170	6	2200	619	100+	8	16	24
3702	76	93	425	3670	10.5	13540	775	18	18	124	3
3703	81	91	550	1240	7	2970	789	79	14	74	3
3704	84	99	450	950	5.5	1440	194	100+	6	8	67
3705	87	88	515	1880	6	5340	509	100+	13	39	6
3706	89	89	560	2040	5.5	3650	553	100+	10	17	24
3707	91	87	480	1080	6.5	1780	239	100+	12	12	109
3708	92	91	455	1250	5	3090	372	100+	55	113	3
3709	93	89	515	990	5	1720	222	100+	14	15	36
3710	96	93	470	1120	5	2280	294	100+	40	75	22
3711	100	88	410	2080	6	8410	420	100+	121	450	1

TABLE G Continued

Tentative Specification Test Results on Bureau 85-100 Grade Test Series

Sacto. Res. No.	Bureau No.	Original Sample Tests				Rolling Thin Film Test			Durability Test		
		Pen. 77°F	Flash PMCT	Visc. 140°F Poises	Stain No.	Viscosity 140°F Poises	Viscosity 275°F CS	Stand. Duct. cm.	Viscosity SR=0.05 Sec $^{-1}$ M.P.	Viscosity SR=0.001 Sec $^{-1}$ M.P.	Micro-Ductility mm
Specification Requirements		-	475 Min	-	10 Max	4000-6000	425-800	75 Min	25 Max	60 Max	10 Min
3712	101	93	430	1180	7.5	2840	409	100+	18	51	10
3713	103	91	400	2070	7.5	10510	863	84	232	1230	0
3714	105	93	430	1340	9.5	4120	458	100+	28	87	6
3715	108	89	520	1550	6.5	3470	453	100+	20	31	29
3716	109	87	530	680	31+	2540	265	59	12	55	4
3717	111	89	535	1610	8	5230	446	100+	14	36	8
3718	115	88	510	1100	6	2870	777	94	20	85	4
3719	119	92	400	830	31+	2480	308	100+	245	2860	0

TABLE H

Tentative Specification Test Results on AC Test Series

Sacto. Res. No.	Bureau No.	Grade	Original Sample Tests: Pen. 77°F	Original Sample Tests: Flash PMCT	Original Sample Tests: Visc. 140°F Poises	Original Sample Tests: Stain No.	Rolling Thin Film Test: Viscosity 140°F Poises	Rolling Thin Film Test: Viscosity 275°F CS	Rolling Thin Film Test: Stand Duct. CM	Durability Test: Viscosity SR=0.05 Sec^{-1} M.P.	Durability Test: Viscosity SR=0.001 Sec^{-1} M.P.	Durability Test: Micro-Ductility MM
Specification Requirements			-	475 Min	-	10 Max	4000-6000	425-800	75 Min	25 Max	60 Max	10 Min
3912	2908	GRADE AC 5	118	525	761	5.5	2091	386	100+	8	20	13
3943	2920		118	410	753	6	1870	405	100+	8	16	12
3916	2958		174	515	660	10	2002	420	100+	6	16	8
3945	2962		183	565	605	6	1601	343	100+	5	9	25
3920	2974		58	375	655	7	1648	349	53	16	66	5
3922	3008		153	450	598	6	1491	356	100+	7	12	12
3947	3012		170	570	646	6	1147	371	100+	3	4	33
3949	3028		122	490	759	6	2039	370	100+	10	21	11
3927	3037		133	485	566	7	1058	300	100+	3	4	48
3928	3050		208	450	605	7.5	1800	442	100+	11	28	12
3932	3054		104	325	561	8	1503	305	100+	14	45	7
3936	3058		168	465	639	6	1565	391	100+	6	12	19
3940	3108		131	470	715	4	1742	344	100+	16	37	13
4080	3578		151	375	701	7	1604	266	100+	44	88	11
4076	3601		122	425	680	5	1076	290	100+	4	6	71
3913	2909	GRADE AC 10	84	490	1360	5.5	3968	499	100+	15	38	7
3944	2921		79	420	1193	3.5	3485	535	100+	13	41	8
3917	2959		110	490	1415	10	4541	682	81	11	36	8
3946	2963		108	425	1268	6.5	3507	494	100+	12	26	8
3921	2975		31	500	1485	6	4025	514	17	43	220	4
3923	3009		92	565	1390	7	4178	550	100+	10	34	6
3948	3013		106	465	1216	5.5	2522	520	100+	9	14	40
3950	3029		89	450	1192	6	4089	504	100+	15	47	5
3952	3036		80	415	1293	5.5	2463	450	100+	14	17	38
3929	3051		129	460	1252	6.5	4387	684	100+	24	81	8
3933	3055		48	510	1257	9	2962	424	100+	32	106	7
3937	3059		110	460	1246	8	3449	533	100+	14	33	7
3941	3109		88	485	1321	4.5	3449	485	100+	28	71	9

TABLE H Continued
Tentative Specification Test Results on AC Test Series

Sacto. Res. No.	Bureau No.	Grade	Original Sample Tests				Rolling Thin Film Test			Durability Test		
			Pen. 77°F	Flash PMCT	Visc. 140°F Poises	Stain No.	Viscosity 140°F Poises	Viscosity 275°F CS	Stand. Duct CM	Viscosity SR=0.05 Sec $^{-1}$ M.P.	Viscosity SR=0.001 Sec $^{-1}$ M.P.	Micro-Ductility MM
Specification Requirements				475 Min		10 Max	4000-6000	425-800	75 Min	25 Max	60 Max	10 Min
4081	3579	GRADE AC10	95	430	1157	4.5	2399	329	100+	54	116	0
4077	3602	GRADE AC10	65	420	1540	4.5	2592	196	100+	18	18	33
3914	2910	GRADE AC20	65	490	2233	6.5	7707	654	90	26	109	4
3915	2922	GRADE AC20	50	440	2409	4.5	7706	692	52	31	192	4
3918	2960	GRADE AC20	86	510	1973	8.5	5938	768	100+	15	55	6
3919	2964	GRADE AC20	70	495	2725	8	7366	689	100+	20	69	8
3924	3010	GRADE AC20	70	575	2723	8	10718	790	35	12	61	3
3925	3014	GRADE AC20	76	525	2208	5	4965	692	100+	17	37	13
3926	3030	GRADE AC20	53	465	3163	6	11750	795	100+	30	132	3
3951	3035	GRADE AC20	43	420	2710	6	5488	633	100+	33	54	23
3930	3052	GRADE AC20	80	460	2581	5	8280	947	100+	50	150	3
3934	3056	GRADE AC20	33	515	2530	10	5563	576	90	73	260	1
3938	3060	GRADE AC20	72	465	2586	8	7703	800	100+	22	79	4
3942	3110	GRADE AC20	68	490	2285	5	6755	639	100+	46	191	3
4082	3580	GRADE AC20	58	440	2292	3	5117	449	100+	130	320	0
4078	3603	GRADE AC20	40	470	2817	5.5	4574	386	100+	50	57	4
3931	3053	GRADE AC40	56	460	5286	5.5	18818	1332	100+	75	300	2
3935	3057	GRADE AC40	20	525	5097	6.5	12612	827	0	330	870	1
3939	3061	GRADE AC40	50	445	5318	6	18321	1149	100+	45	225	3
4079	3604	GRADE AC40	31	500	5871	4	10433	582	100+	161	345	0

TABLE I

Asphalts Complying With The Tentative Specifications Except For The Micro-ductility Requirement

Sacto Res. No.	Bureau No.	Grade	Source	Flash PMCT °F	Stain No.	Rolling Thin Film Test			Durability Test		
						Viscosity			Viscosity		Micro
						140°F Poises	275°F CS	Stand Duct CM	SR=0.05 Sec^{-1} M.P.	SR=0.001 Sec^{-1} M.P.	Ductility mm
Specification Requirements				475 Min.	10 Max	4000-6000	425-800	75 Min	25 Max	60 Max	10 Min.
3688	19	85-100	Venezuela	510	8.5	4850	575	100+	18	43	8
3692	38	"	Midcontinent	510	7.5	4230	519	100+	12	39	5
3697	66	"	Kansas	485	7.5	6400	653	100+	12	52	4
3705	87	"	Oklahoma	515	6	5340	509	100+	13	39	6
3717	111	"	Wyoming	535	8	5230	446	100+	14	36	8
3917	2959	AC10	-	490	10	4541	682	81	11	36	8
3923	3009	"	-	565	7	4178	550	100+	10	34	6
3918	2960	AC20	-	510	8.5	5938	768	100+	15	55	6
3925	3014	"	-	525	5	4965	692	100+	17	37	13

CHANGE IN KINEMATIC VISCOSITY DURING CALIFORNIA ROLLING THIN FILM TESTS
AC Series–Grade AC20

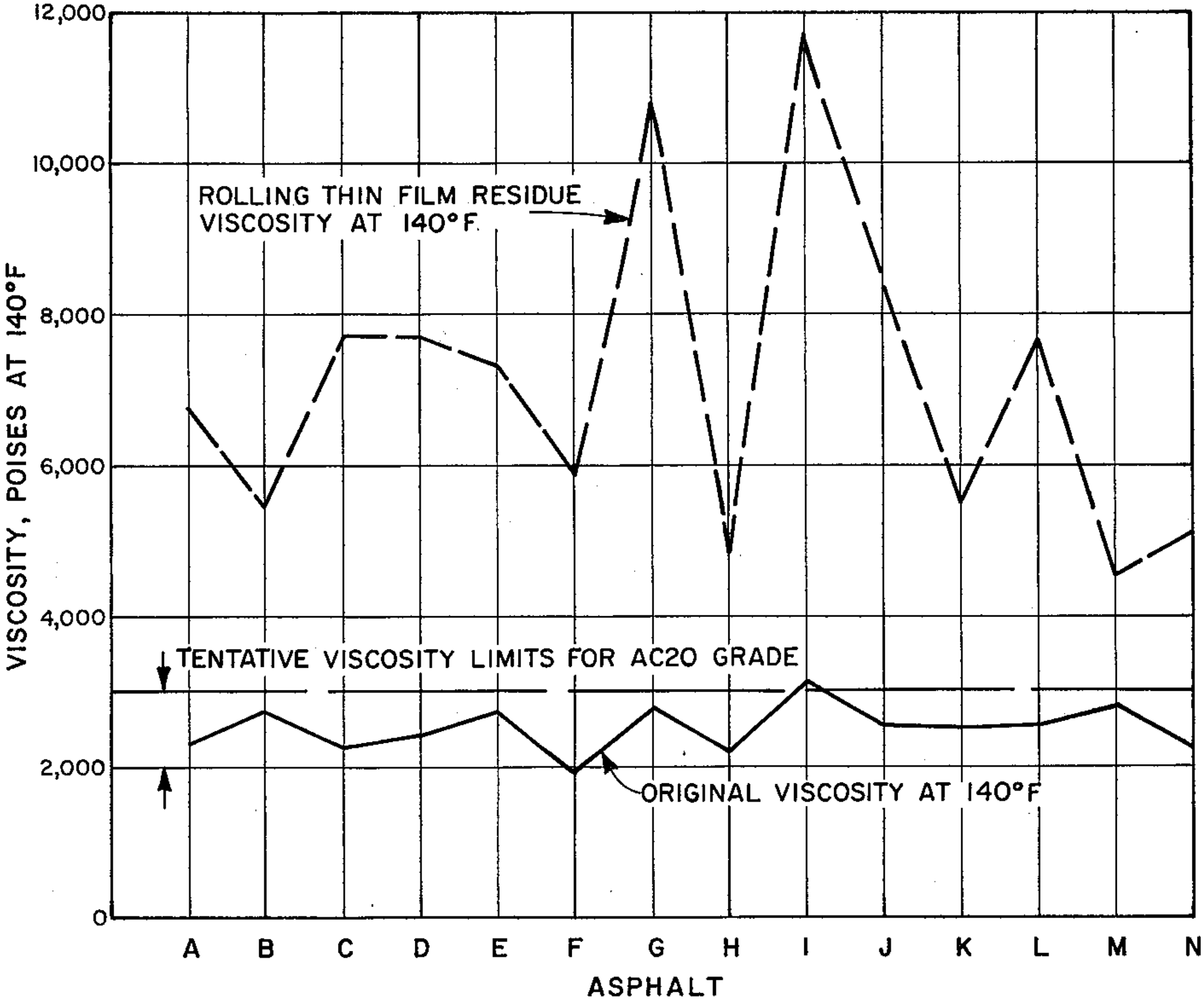
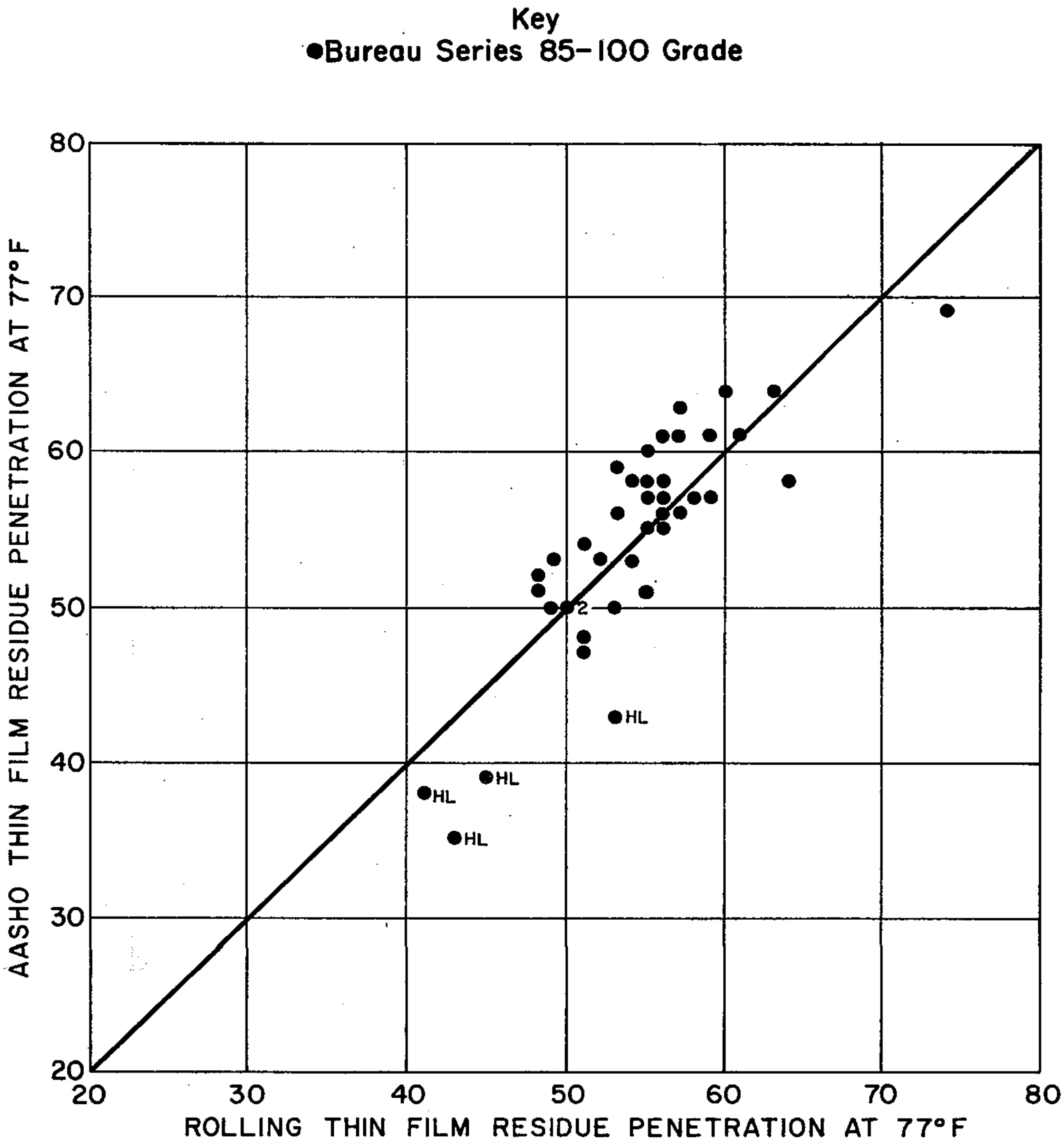


FIGURE I

COMPARISON OF CALIFORNIA ROLLING THIN FILM TEST AND AASHO THIN FILM OVEN TEST RESIDUE PENETRATIONS



Note: HL=High Loss in Standard Thin Film Test

FIGURE 2

COMPARISON OF CALIFORNIA ROLLING THIN FILM TEST AND AASHO THIN FILM OVEN TEST RESIDUE PENETRATIONS

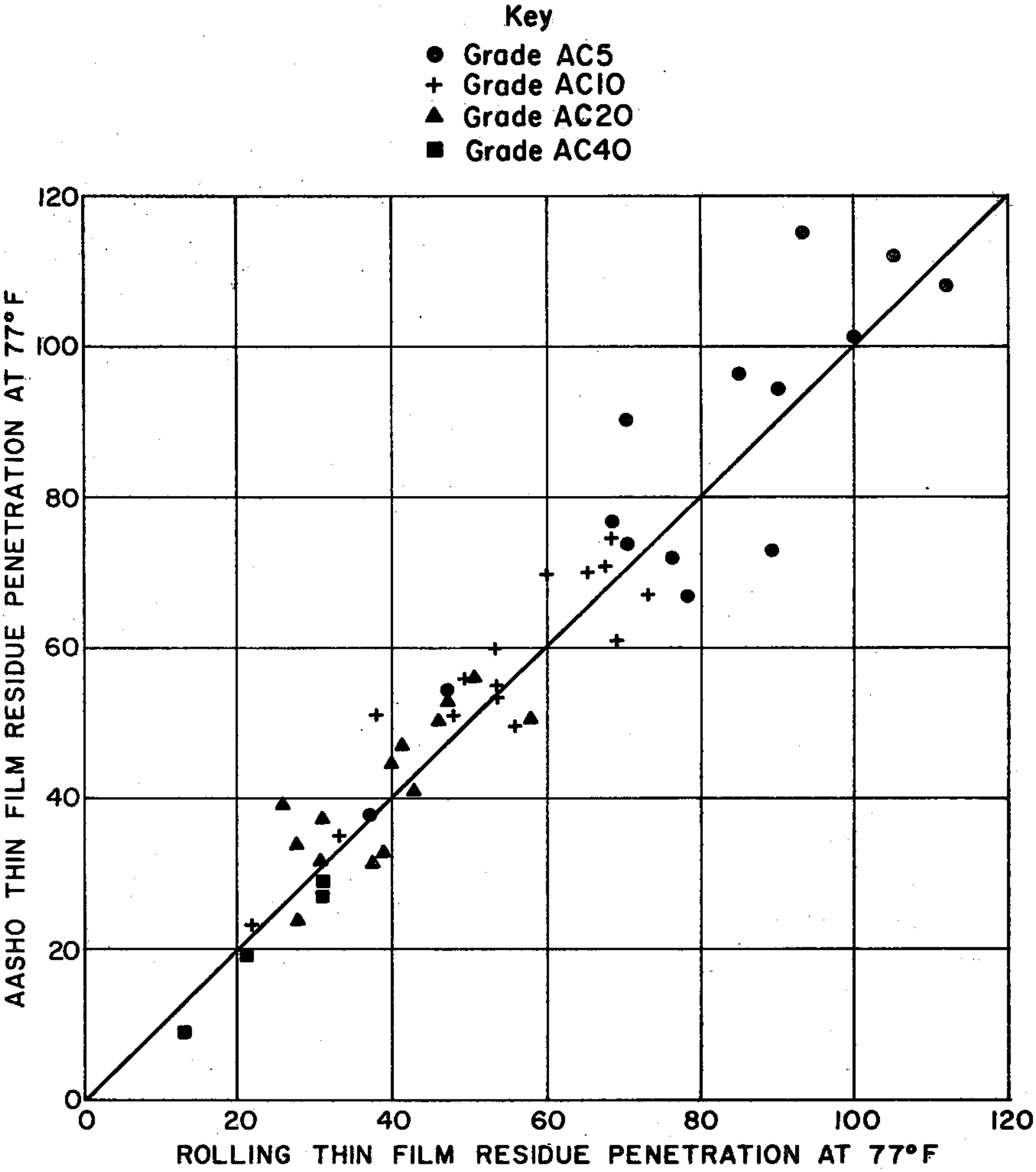


FIGURE 3

COMPARISON OF CALIFORNIA ROLLING THIN FILM TEST AND AASHO THIN FILM OVEN TEST RESIDUE VISCOSITIES AT 140°F

AC Test Series

Key

● Grade AC 5

+ Grade AC 10

▲ Grade AC 20

■ Grade AC 40

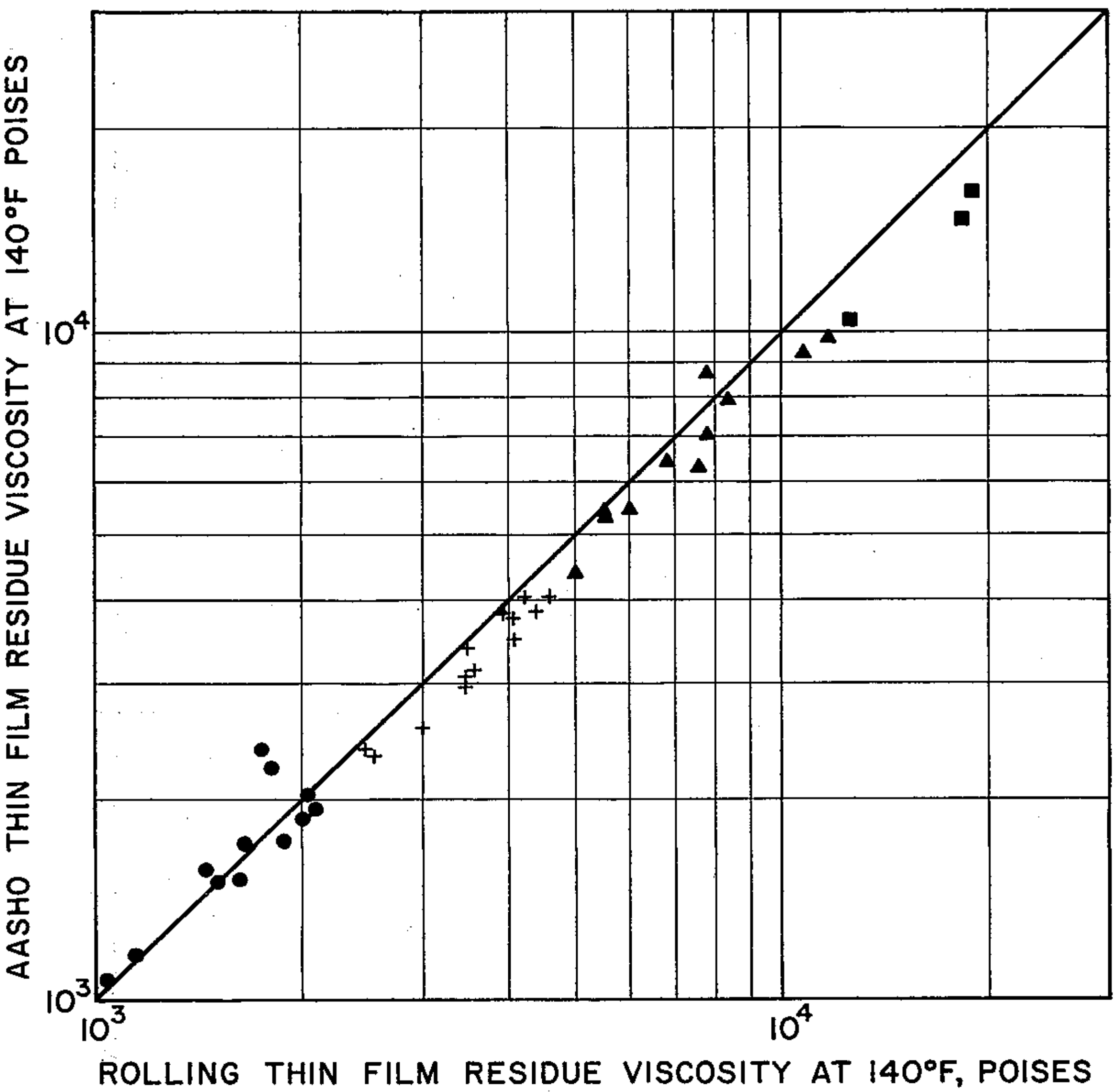


FIGURE 4

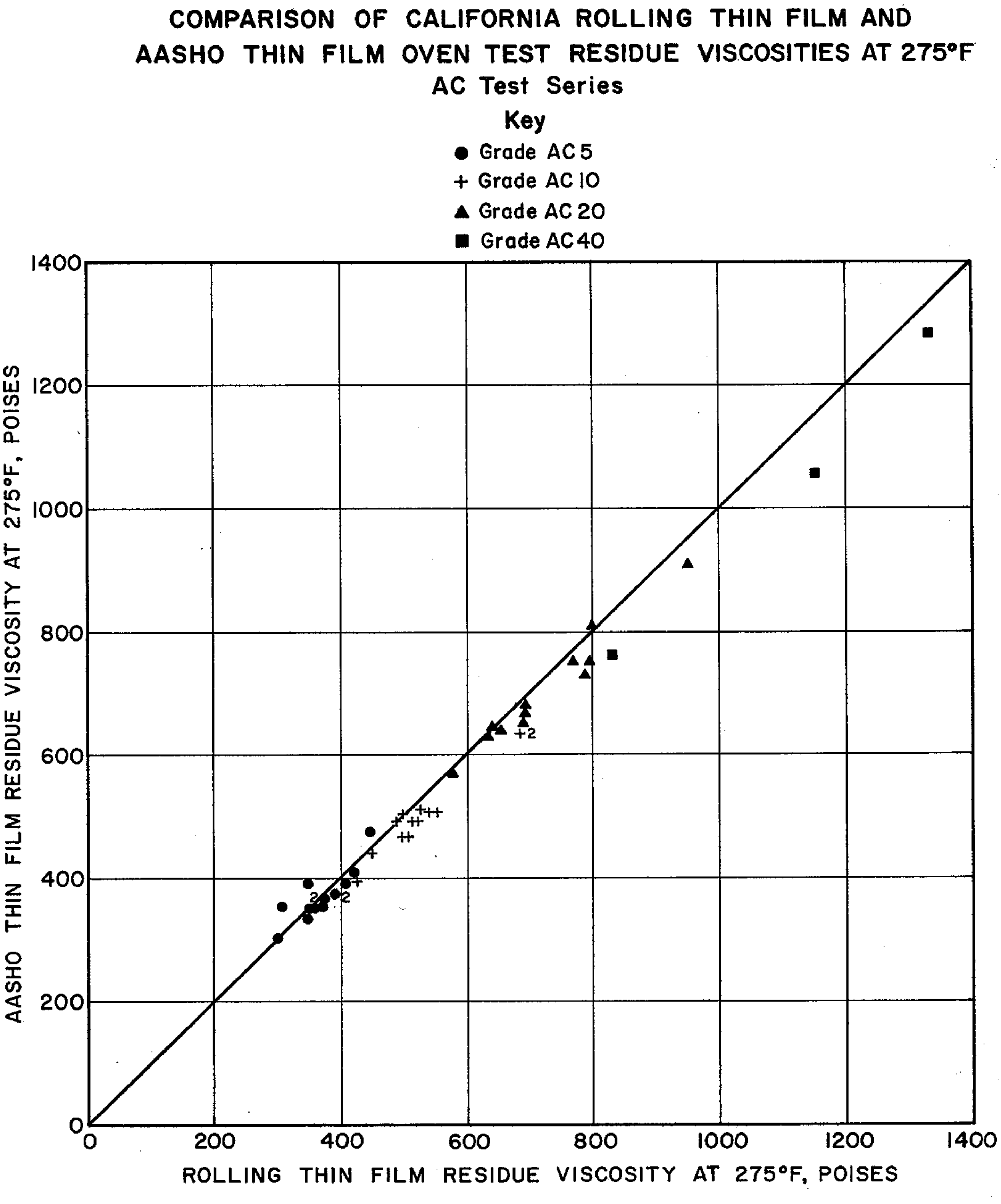

COMPARISON OF CALIFORNIA ROLLING THIN FILM AND
AASHO THIN FILM OVEN TEST RESIDUE VISCOSITIES AT 275°F
AC Test Series
Key
Grade AC 5
Grade AC 10
Grade AC 20
Grade AC 40
AASHO THIN FILM RESIDUE VISCOSITY AT 275°F, POISES
ROLLING THIN FILM RESIDUE VISCOSITY AT 275°F, POISES
0
200
400
600
800
1000
1200
1400
2
2
2

FIGURE 5

TYPICAL CHANGES IN PHYSICAL PROPERTIES OF
GROUP I ASPHALTS DURING WEATHERING
Sample R 3680 – Bureau #2
Venezuela Crude

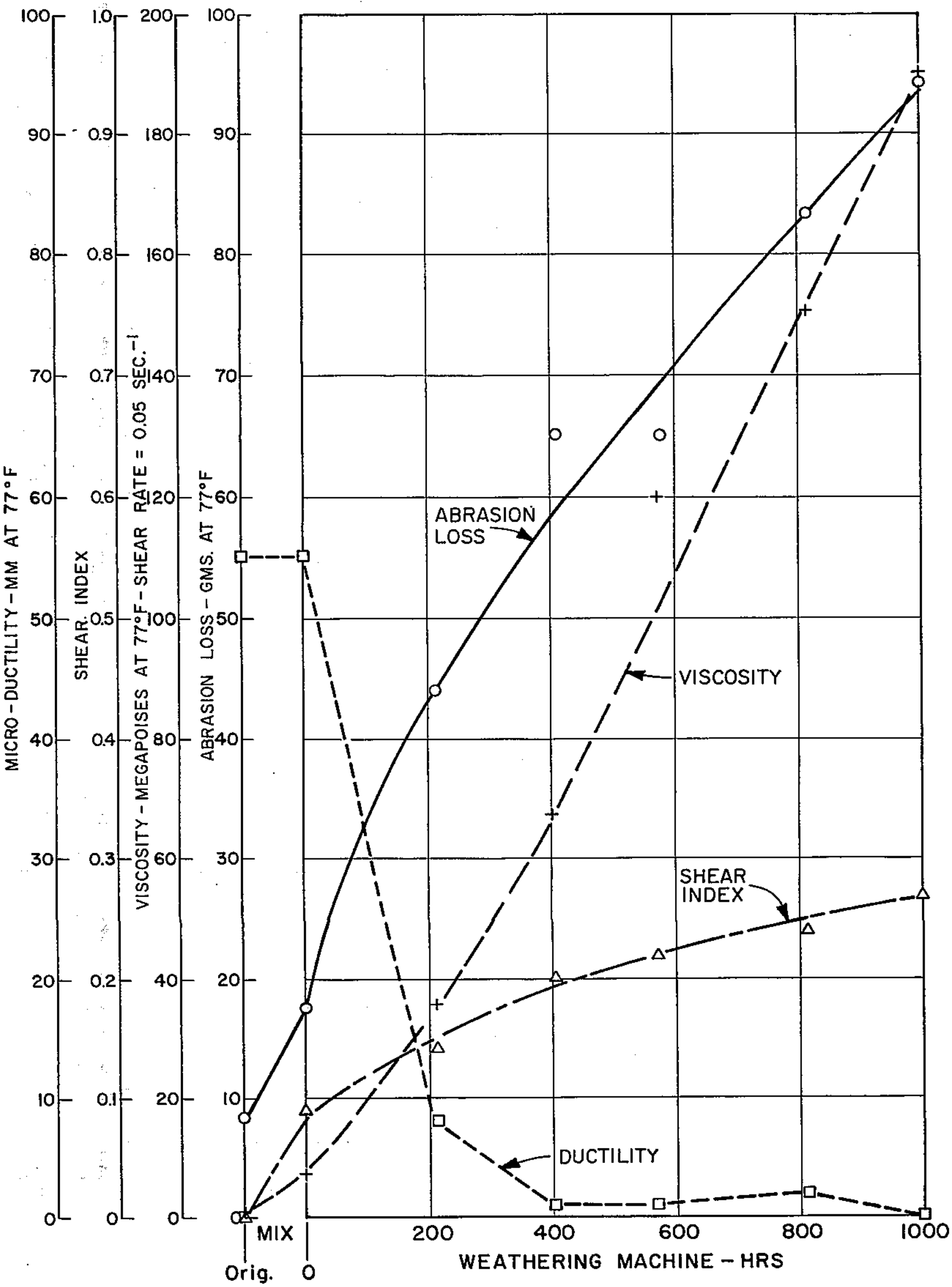


FIGURE 6

TYPICAL CHANGES IN PHYSICAL PROPERTIES
OF GROUP II ASPHALTS DURING WEATHERING
SAMPLE R3682-BUREAU #4
VENEZUELA CRUDE

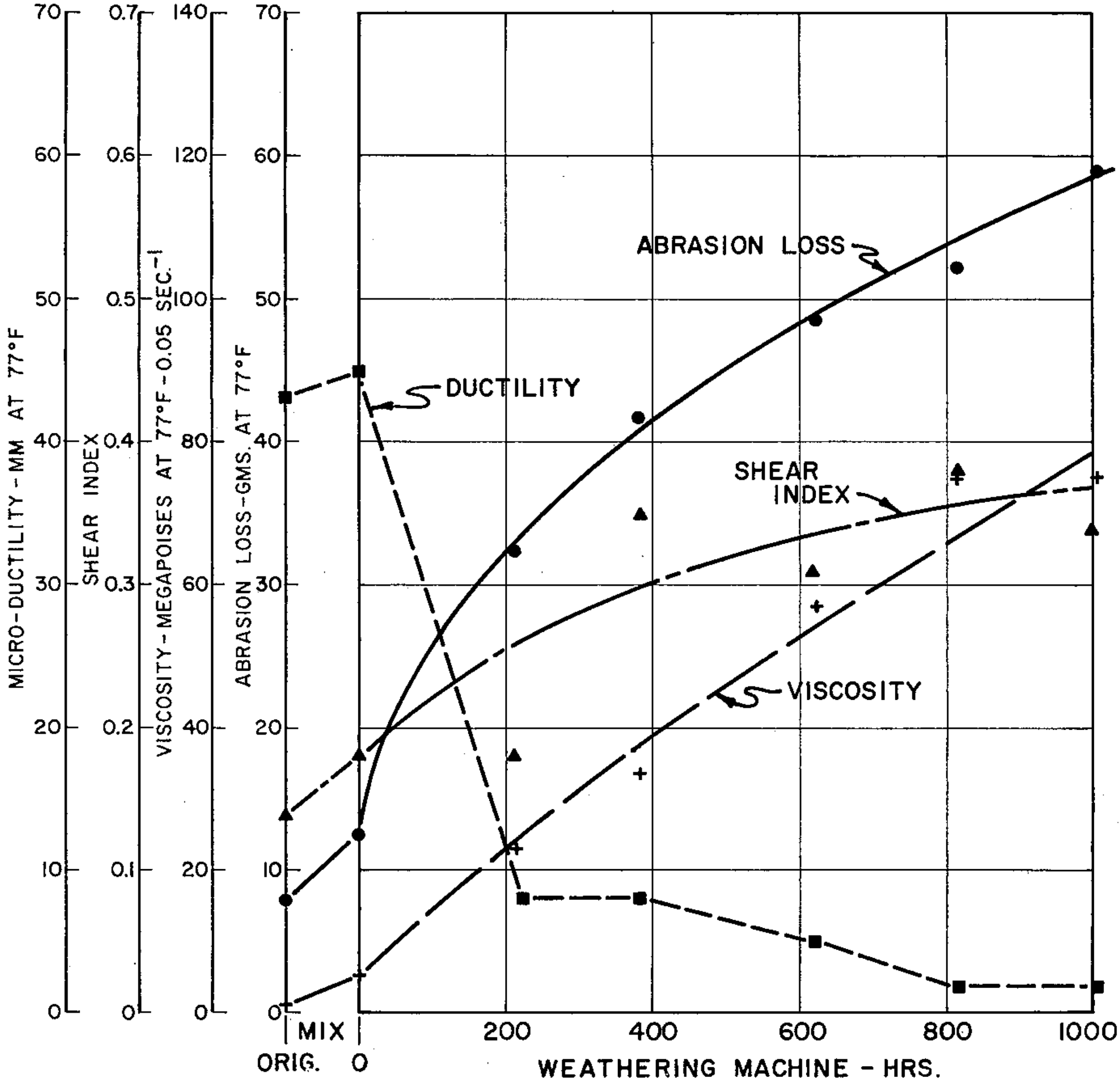


FIGURE 7

TYPICAL CHANGES IN PHYSICAL PROPERTIES OF GROUP III ASPHALTS DURING WEATHERING

SAMPLE R3864-BUREAU #10
COASTAL CRUDE

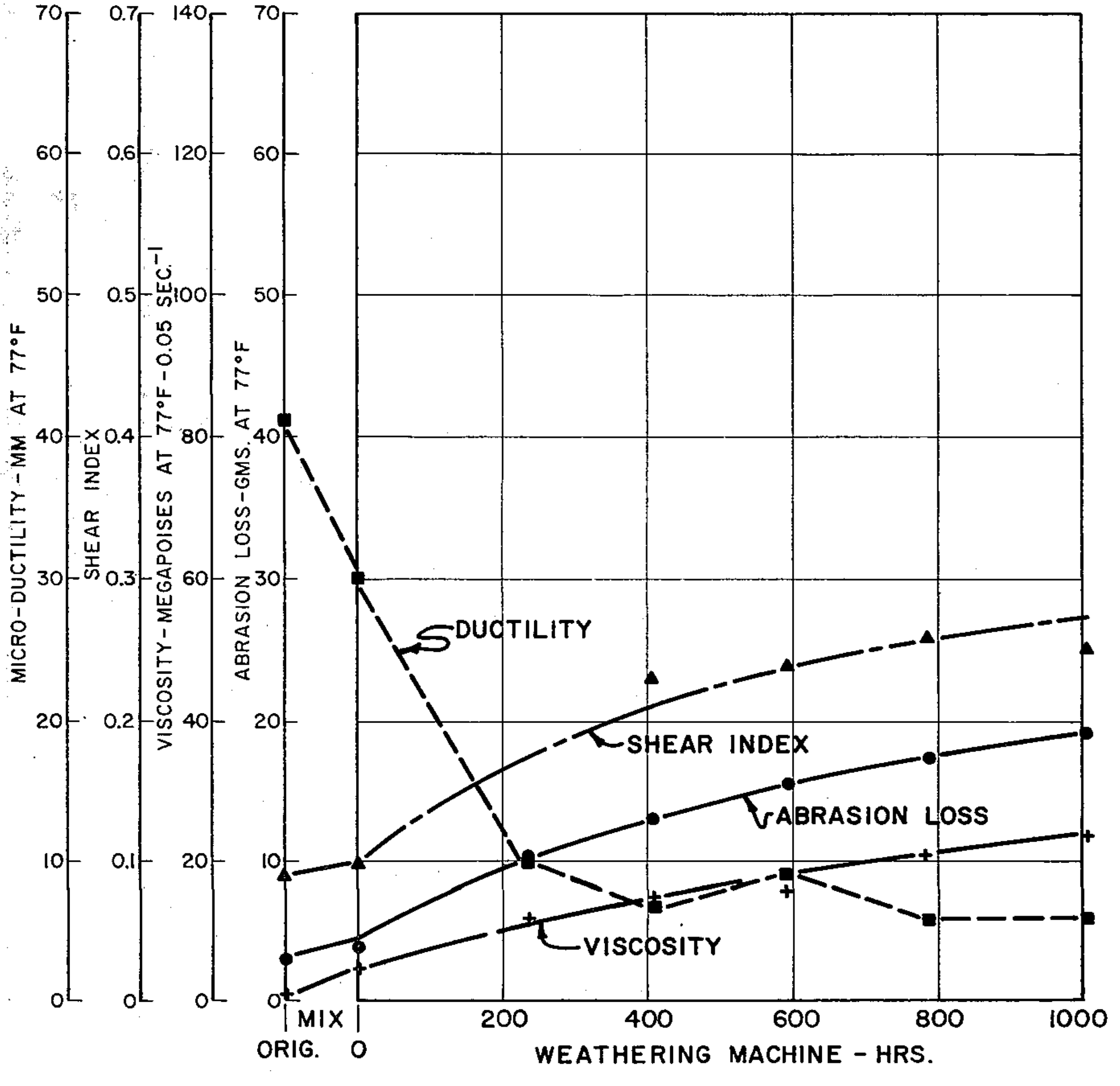


FIGURE 8

TYPICAL CHANGES IN PHYSICAL PROPERTIES
OF GROUP IV ASPHALTS DURING WEATHERING

SAMPLE R3703-BUREAU #81
TEXAS-KANSAS CRUDE

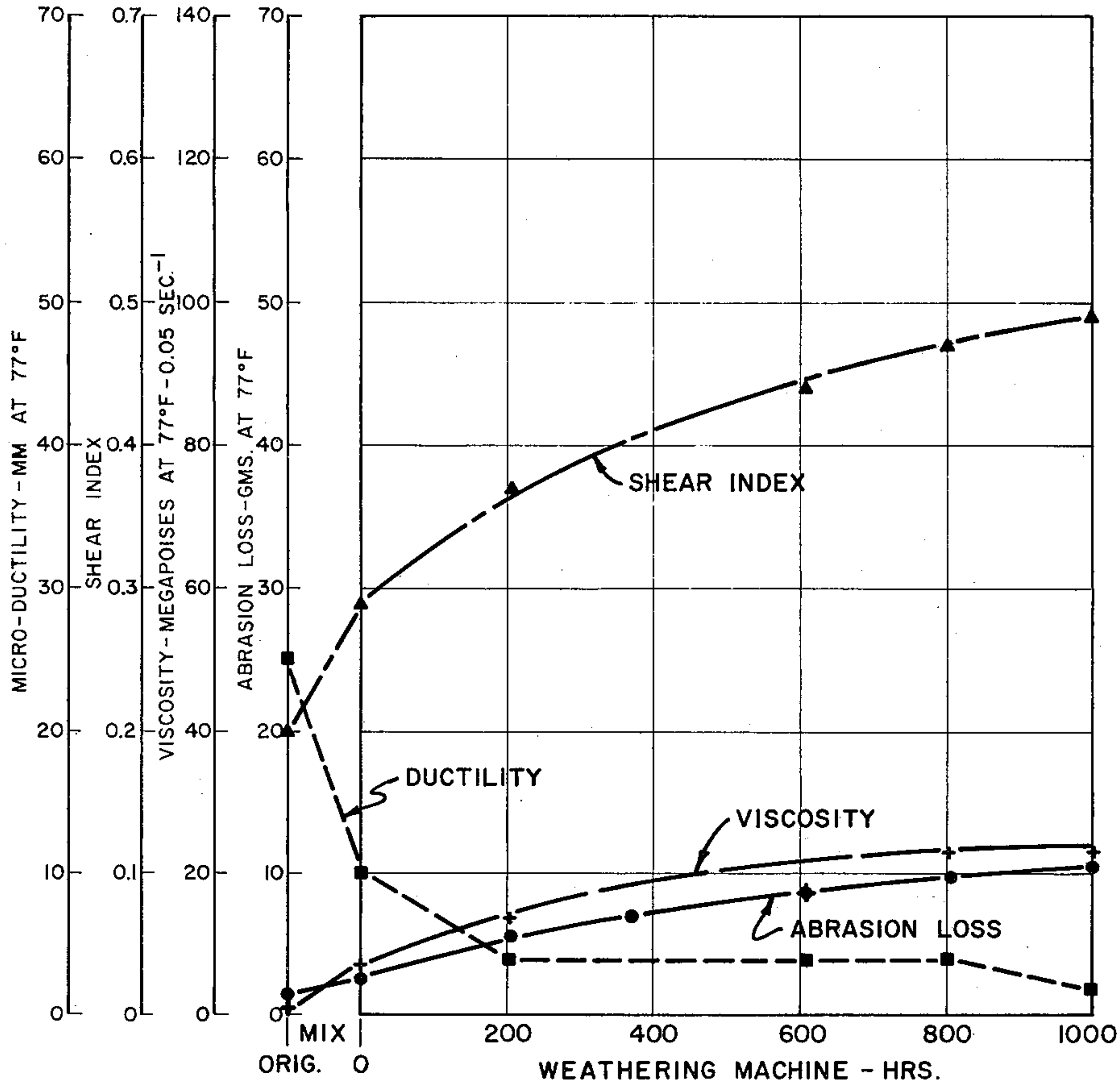


FIGURE 9

TYPICAL CHANGES IN PHYSICAL PROPERTIES
OF GROUP V ASPHALTS DURING WEATHERING

SAMPLE R3707-BUREAU #91

CALIFORNIA CRUDE

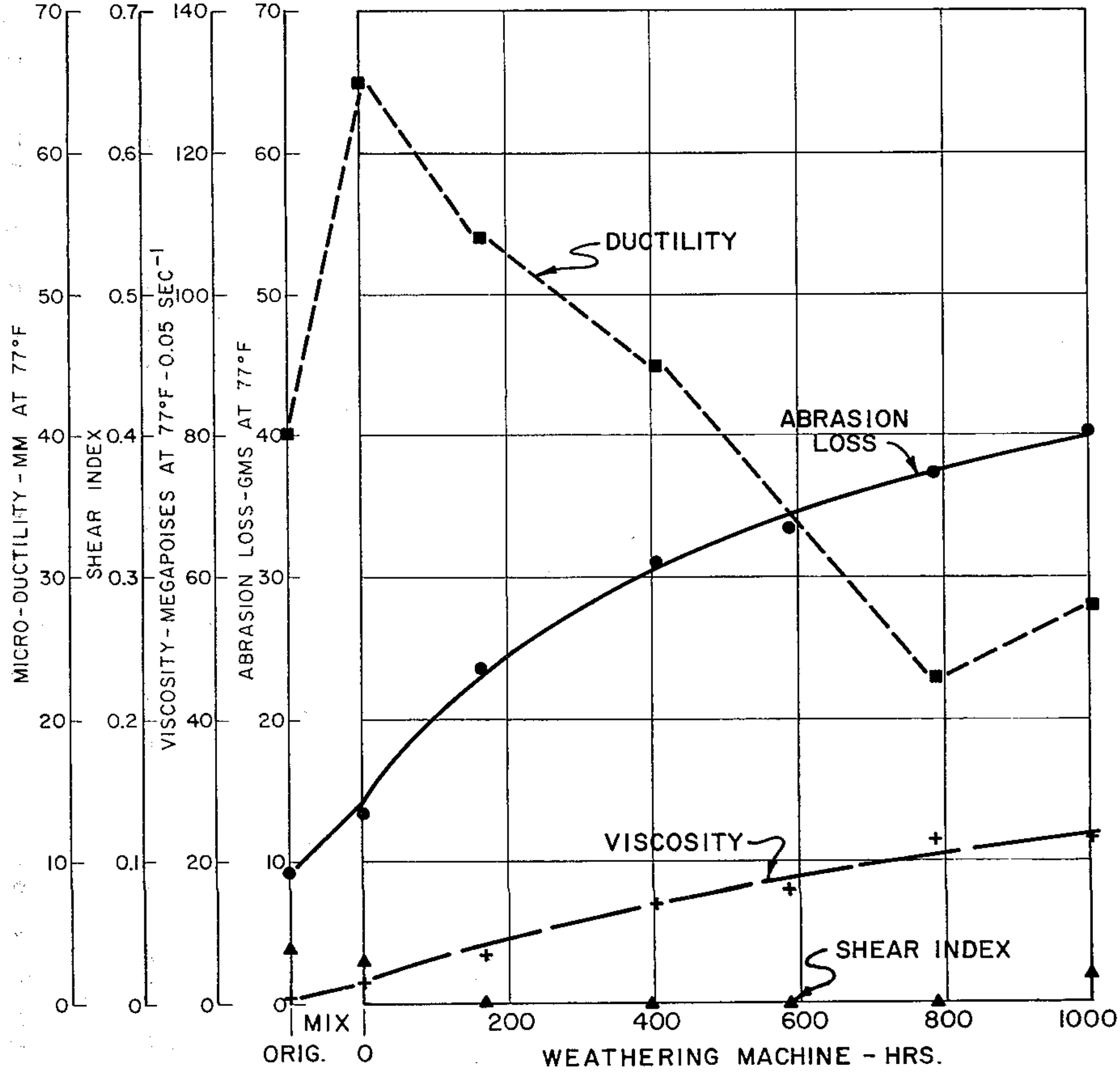


FIGURE 10

CHANGE IN SHEAR INDEX DURING WEATHERING
GROUP IV ASPHALTS COMPARED WITH DOYLE SERIES

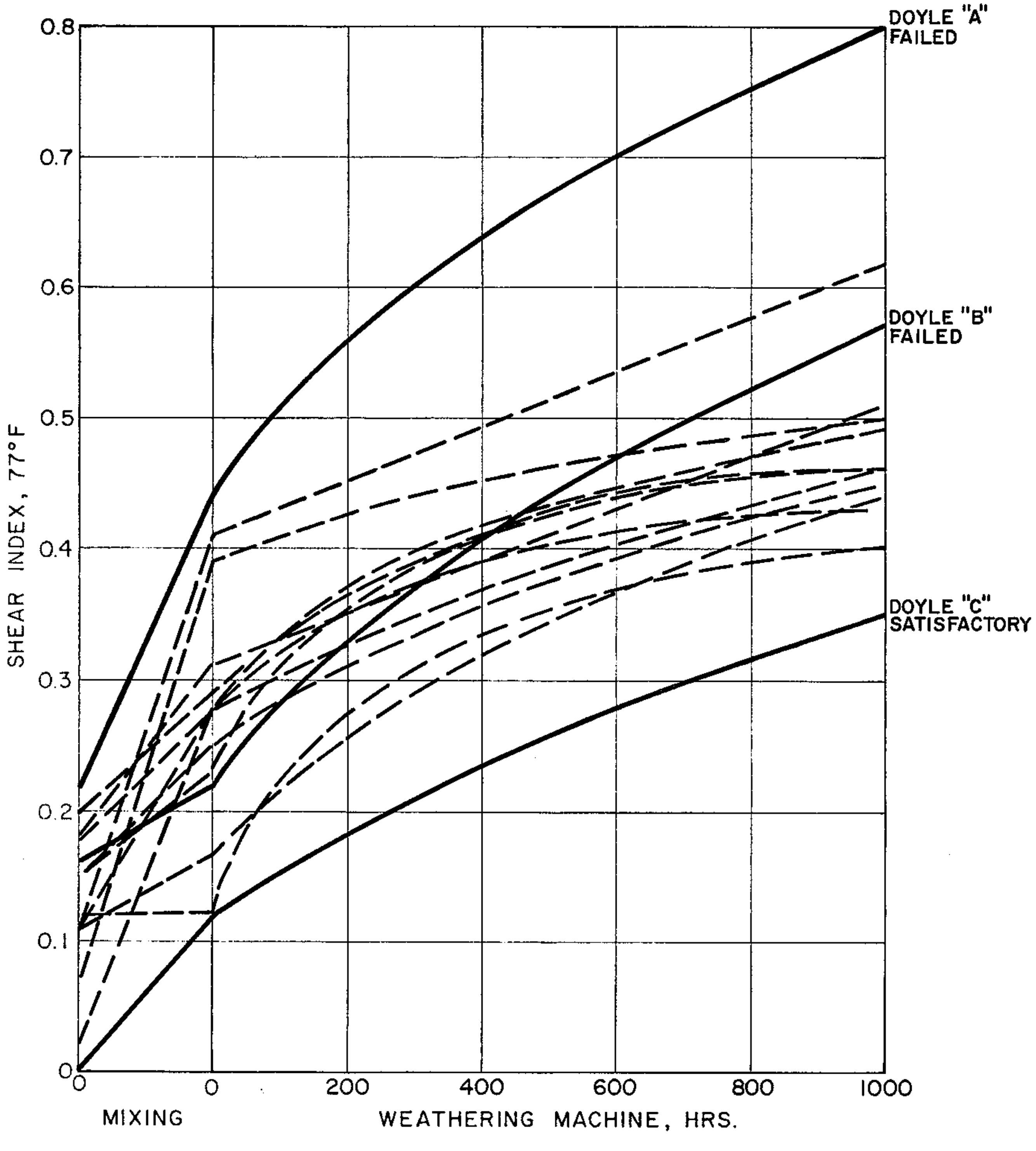
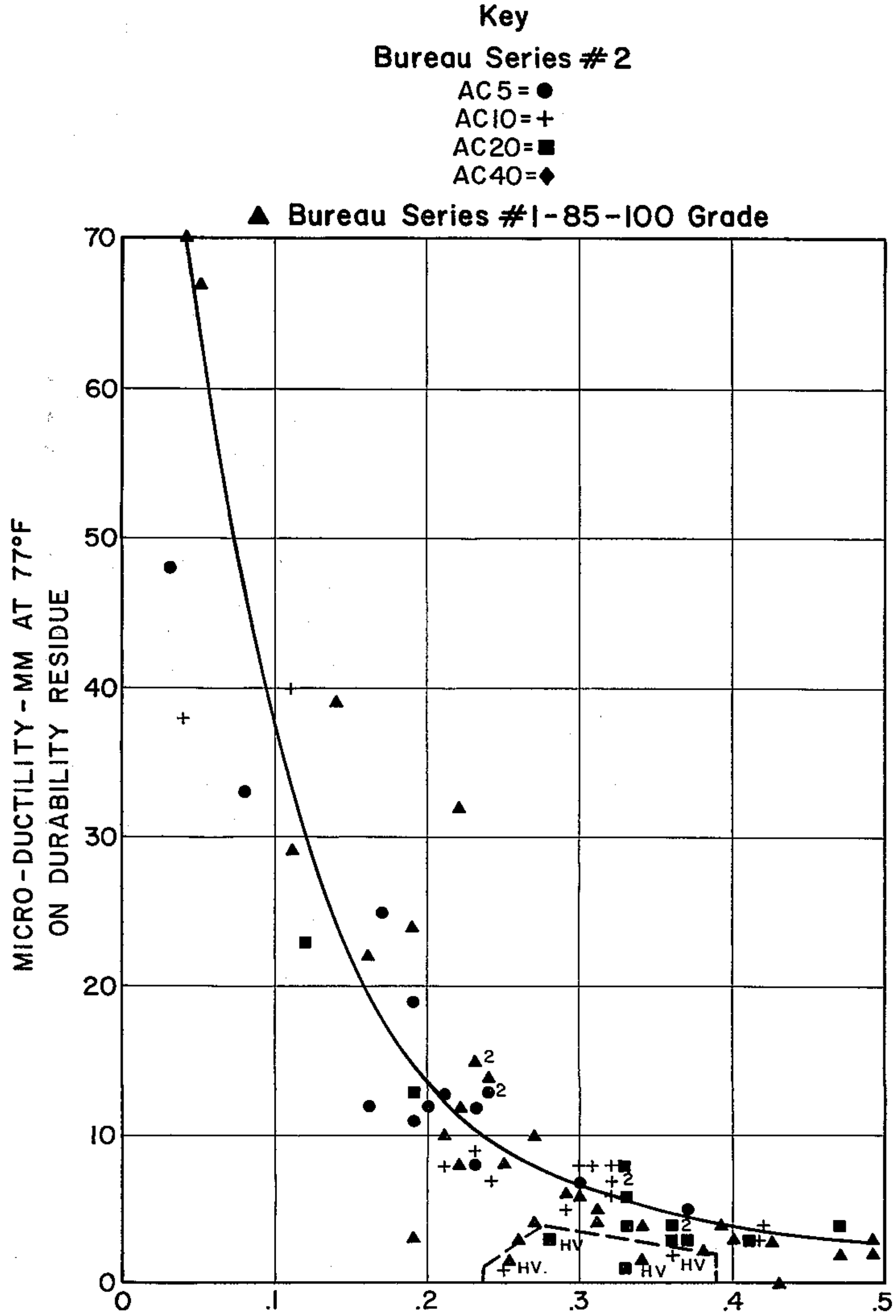


FIGURE 11

MICRO-DUCTILITY-SHEAR INDEX RELATION ON DURABILITY TEST RESIDUE



NOTE - HV = Viscosity of Residue very high.

FIGURE 12

COMPARISON OF ORIGINAL STAIN NUMBER WITH SHEAR INDEX AFTER WEATHERING

Bureau Series #1, 85-100 Grade

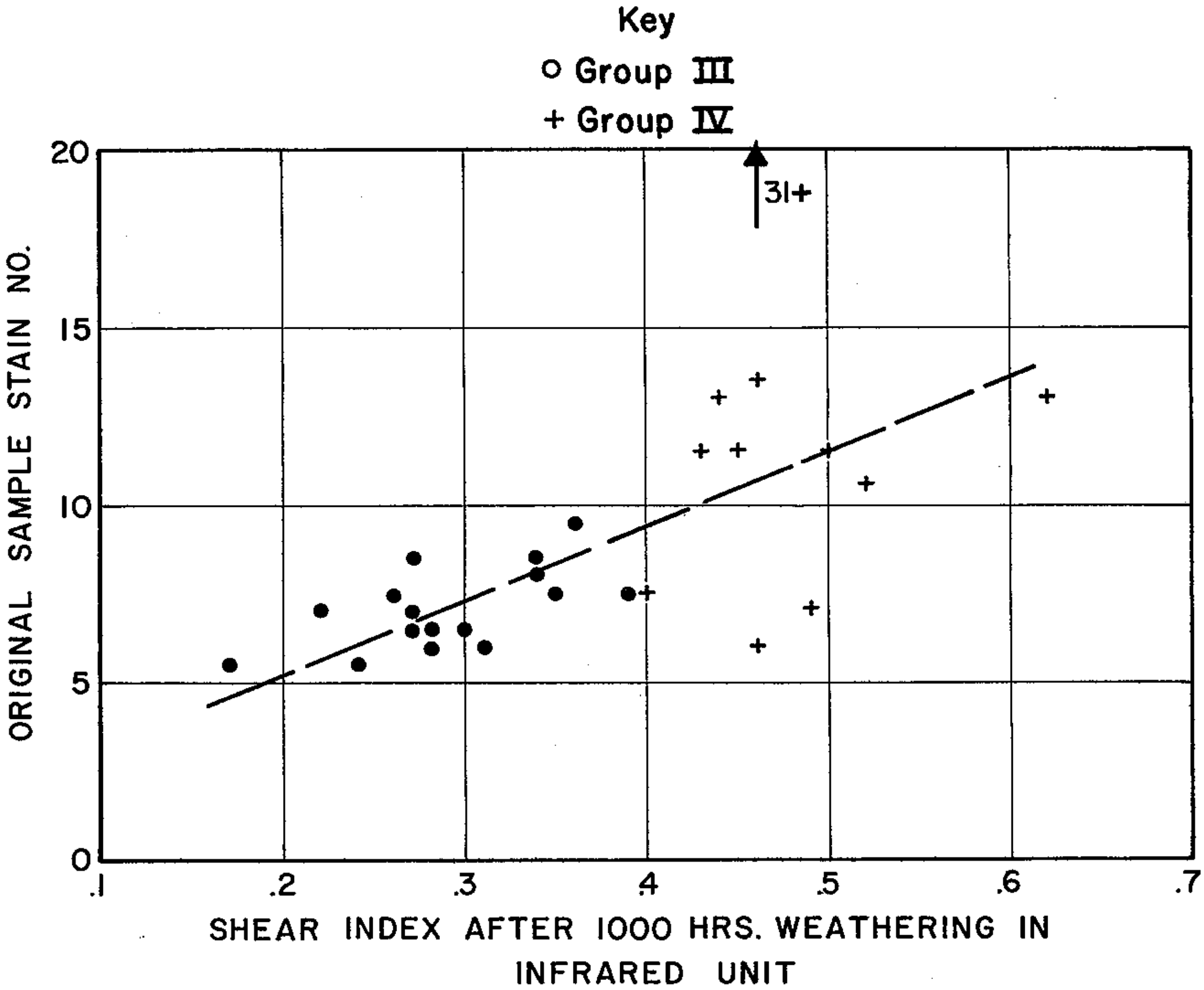


FIGURE 13